agree with the photograph and its center is a point on the true horizon supposed to be the place of the sun. The slight eccentricity of the sun in the photograph is due to a fault of direction in the camera. The fainter vertical column of light directly above the sun is a secondary phenomenon due to these same crystals; in other words, it is the sum of images of the two tangent arcs formed by A′ crystals and, of course, colorless. This is the only certainly established secondary phenomenon excepting the parhelia at approximately 90° right and left of the sun, which are represented in figure 5 above and which have frequently been recorded.

The question as to whether a feature is prismatic or without color is easy to answer from the mode of its production. In general, if produced by refraction we may expect attendant color unless the refraction at entry and emergence from the crystal is compensatory, as in the parhelic circle, the paranthelia and the anthelia. Of course, all very faint arcs would fail to betray colors for quite the same reason that the lunar rainbow does so.

In the above theory explanations for all the well authenticated features of halos are given with the single exception of the rarely observed concentric circles about the sun of radii differing from 22°. These may be due to the presence of crystals of which the rhombohedral faces are developed—and indeed, Bravais has attempted to explain them in this way—but such crystals, although next in crystalographic simplicity to the hexagonal prisms assume as the bases of the theory here developed, have never been observed and therefore lie outside the proper scope of this paper.[7]

BEAUTIFUL HALO DISPLAY OBSERVED AT ELLENDALE, N. DAK.

By FRANK J. BAVENDICK, Observer.

[Dated Weather Bureau, Ellendale, N. Dak., Mar. 22, 1920.]

Interesting and unusual solar halo forms were observed at Ellendale, N. Dak., on March 8, 1920. About 11:30. a. m. a 22° halo began forming and by 1:15 p. m. this halo (a a) figure 1, was complete and other optical phenomena were developing. At 1:30 p. m. the sky appeared as in the drawing, figure 1. The arcs (c, c′) were parts of a circumscribed halo. The 22° halo and these arcs had brilliant spectral colors; the red being nearest the sun. The infralateral arcs (i, i′) were 38° long and extended to 7° above the southern horizon. They had rainbow colors with the red nearest the sun. The large white parhelic circle (mm) was well defined and was accompanied by the oblique arcs of the anthelion (r, r′; s, s′). These were also white and well defined, but were not as distinct and did not remain for so long a time as the parhelic circle.

The white ring (xx) was about 32° in radius. Its lower edge was tangent to the 22° halo and other portions were tangent to the arcs (r, r′). The lower half of this circle was about half as bright as the primary parhelic circle (mm) and the upper half was indistinct, but continuous. The intersection of this circle (xx) and the halo (aa) was very brilliant.

The arc (bb) had faint rainbow colors and was about 22° above the halo (aa). Parhelia (e, e′) were observed outside of the halo (aa) and intensified patches were also noticed at the intersections of (aa) and (c, c′) with (mm).

The disappearance of these circles and arcs of circles occurred gradually between 2:30 and 2:45 p. m. The sky was covered with nine-tenths Ci. St. clouds and they were heavier than the usual type of Ci. St. clouds observed when halos are visible here. No precipitation had occurred for five days, but a low was approaching from the northwest. The surface wind at the time of the halo was from the south, the humidity was 65 per cent and the temperature was −4° C. There was a temperature inversion of about 5° C. at 1,000 meters above the surface.

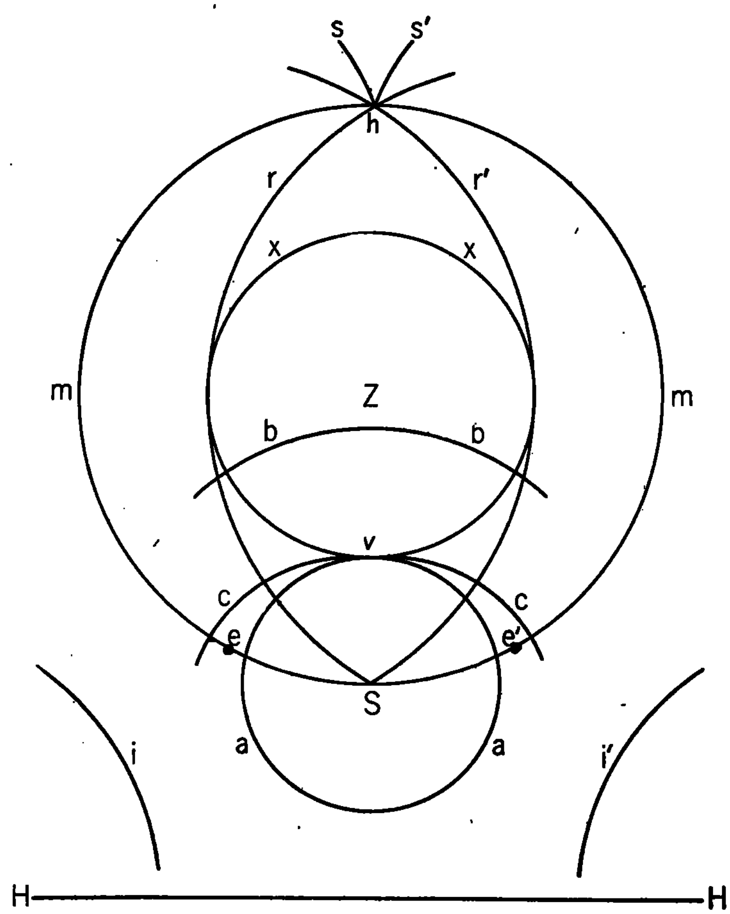

FIGURE 1.—Solar halo phenomena observed at 1:30 p. m., March 8, 1920, at Ellendale, N. Dak., including: Halo of 22° (aa); arc of halo of 46° (bb); arc of circumscribed halo (cc); parhelia of 22° halo (e, e′); anthelion (h); infralateral tangent arcs of 46° halo (i, i′); parhelic circle (mm); two pairs of the oblique arcs of the anthelion (r, r′; s, s′); so-called vertical parhelion of 22° (v); probably secondary parhelic circle (xx). S, sun; Z, zenith; and HH, horizon.

At 3,500 meters the wind was from the west, the humidity about 70 per cent increasing, and the temperature was −15° C.

NOTE.—This description of halo phenomena is of great interest, particularly that portion dealing with the white circle marked (xx). This is presumably what may be called a secondary parhelic circle, induced by the brilliant luminous spot at the summit of the 22° halo; this circle was tangent to the oblique arcs of the anthelion (r, r′). So far as known a complete secondary parhelic circle has never before been observed. In 1896 Rear Admiral A. von Kalmar observed at Pola a portion of this circle,[1] which, if extended, would have been tangent to the oblique arcs of the anthelion.

The observations at Ellendale were made independently by Mr. Bavendick at pilot balloon station "A" and by Mr. Wm. H. Brunkow at the kite house nearby, the angular measurements being determined by means of standard balloon theodolites.

[7] A discussion elucidating some of the more difficult parts of this article will be published in a later issue of the REVIEW.—Editor.

[1] The Different Forms of Halos and their Observation, by Louis Besson. MONTHLY WEATHER REVIEW, July 1914, 42: 444, fig. 20.